# Priddis 3D seismic survey and development of a training centre

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## ABSTRACT

A high-resolution 3D seismic survey was undertaken to map shallow aquifers near Calgary, Alberta. The survey was 500 m x 300 m in area, with shot and receiver lines in an orthogonal geometry using 50 m line separation. Shots and geophones were spaced at 10m intervals along source and receiver lines, respectively. The surface source used was an 18,000 lb EnviroVibe sweeping over a 10 Hz to 180 Hz range. The survey yielded excellent reflections with a dominant frequency of 50 Hz. One high-amplitude east-dipping reflection, occurring between depths of 250 m and 450 m, was mapped over the survey area. The site is currently being reviewed for the development of a geophysical training centre.


## INTRODUCTION

A 3D surface seismic survey, a vertical seismic profile (VSP), and well logs were acquired at a site near Priddis, Alberta, about 30 km southwest of the city of Calgary. The purpose of the program was to map shallow stratigraphy and structure to depths of up to 500m, and to investigate shallow aquifers in the study area. 3D seismic surveys are used more typically to map deeper targets, but this program illustrates the efficacy of the technique for characterizing shallow targets. This paper will focus on the surface seismic program; VSP surveys and well log data from this site are described by (Wong et al., 2008).

The site of the survey is located at the eastern edge of the Rocky Mountain foothills in the triangle zone (Lawton et al., 1996), a structural feature where clastic sediments of dominantly Cretaceous age have been wedged into the foreland basin. Local topography of the area is controlled by sandstone ridges of the Cretaceous Belly River Formations, which trend in a northwesterly direction, along structural strike. Shales of the Upper Cretaceous Edmonton Formation form the bedrock in the intervening valleys. In the study area, Upper Cretaceous and Tertiary strata dip gently towards the southwest. An aerial photograph of the site is provided in Figure 1, covering a quarter-section of land owned by the University of Calgary and home to the Rothney Astrophysical Observatory (buildings shown near the right hand side of the photograph). The 3D seismic survey layout is shown in the southern area, and a 140m deep VSP and logging well was located near the northern access road.

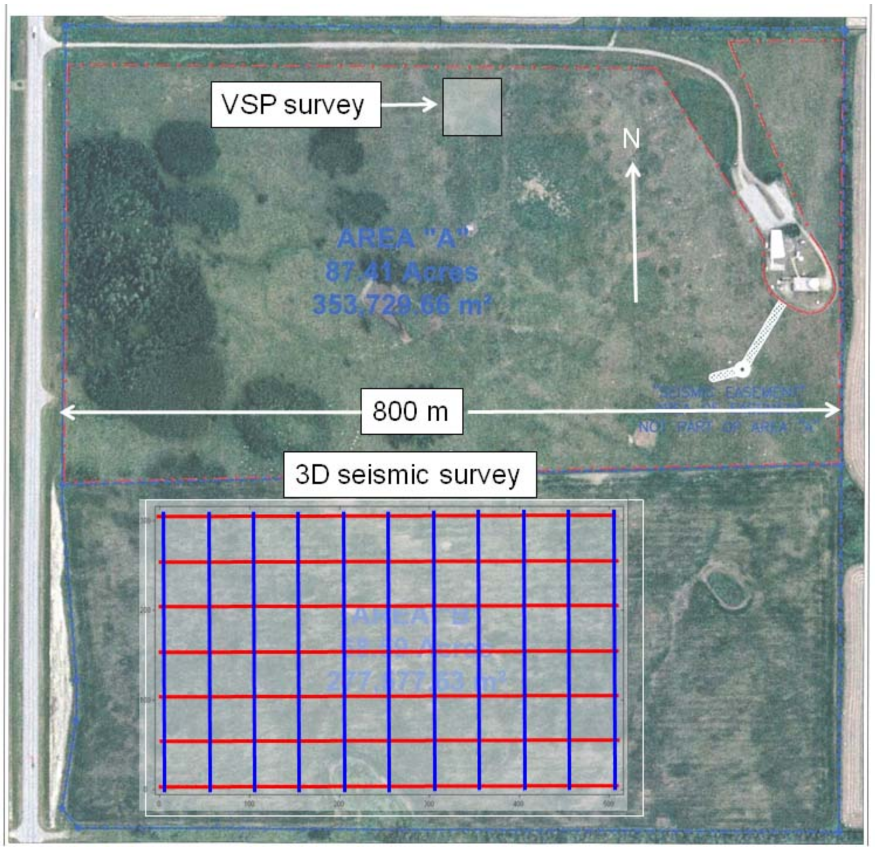



FIG. 1. Site of the Priddis 3D seismic and VSP surveys.

## SEISMIC SURVEY

The seismic survey was designed to image horizons in the depth range of 100 to 500 m. An orthogonal geometry was employed, with receiver lines oriented north-south and source lines oriented east-west. Shot and receiver lines were 50 m apart and shots and receivers were spaces 10 m apart along their respective lines. Shot lines crossed receiver lines midway between geophones and similarly, receiver lines intersected shot lines midway between shots. This approach to recording optimizes array stacking for surface-wave attenuation (Anstey, 1986). The pre-survey schematic layout is shown in Figure 2.

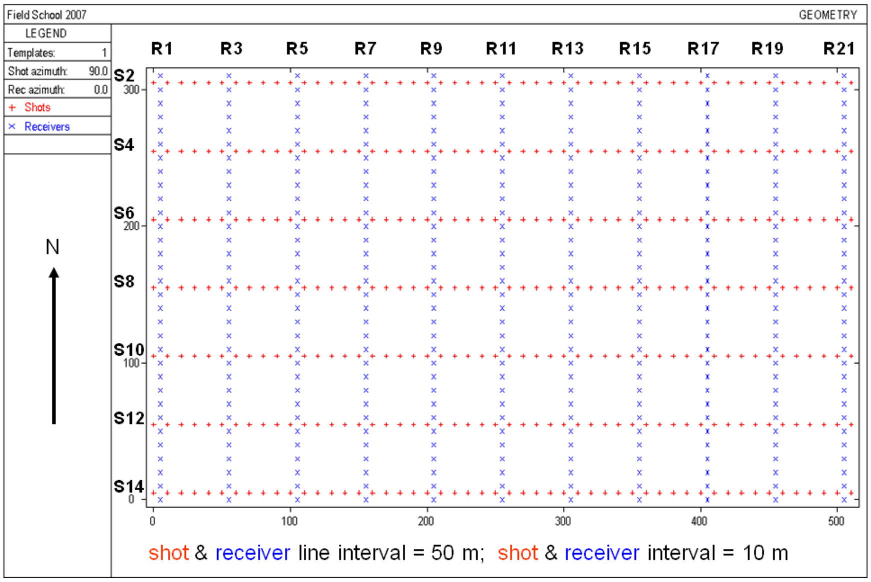



FIG. 2. Pre-survey design for shallow imaging at Priddis, Alberta

Equipment used to record the survey is owned and operated by the University of Calgary. It consists of a 600-channel ARAM Aries recording system and a 17,400 lb EnviroVibe built by IVI. Geophones used were single vertical-component marsh phones containing SM-24 10Hz elements. Figure 3 shows the EnviroVibe source. Various sweep tests were performed at the beginning of the survey and the final source parameters were 4 linear sweeps from 10 Hz to 180 Hz over 12 seconds and a 1 second listen time.


FIG. 3. Envirovibe seismic source used for the 3D survey.

## RESULTS AND DISCUSSION

Data were recorded over a period of 2 days in early Fall weather; the ground surface was stubble and good coupling was achieved between the vibrator base plate and the ground; all shotpoints and receiver locations were surveyed with GPS and Figure 4 shows the post-survey geometry and common-mid-point (CMP) bins. Acquisition took place generally with a rolling receiver pattern, with 3 templates illustrated in Figure 5, and the final CDP fold of the survey is shown in Figure 6.

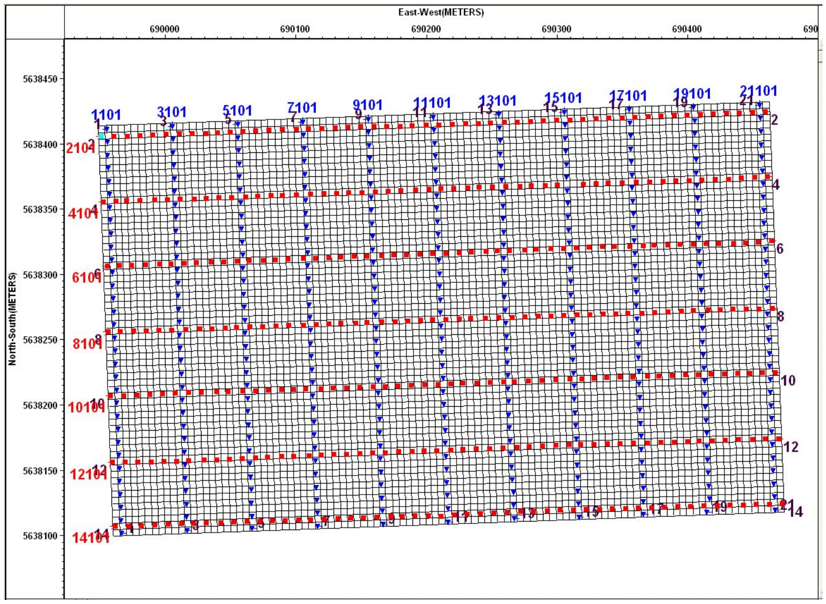
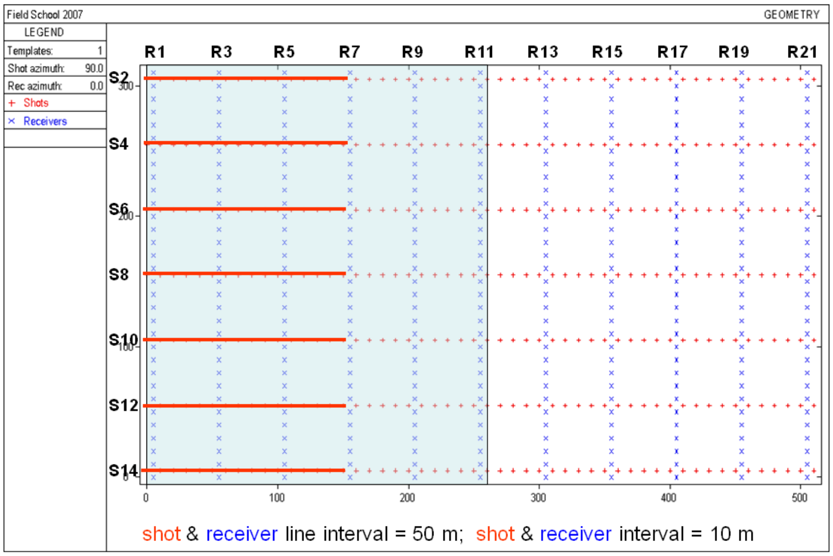
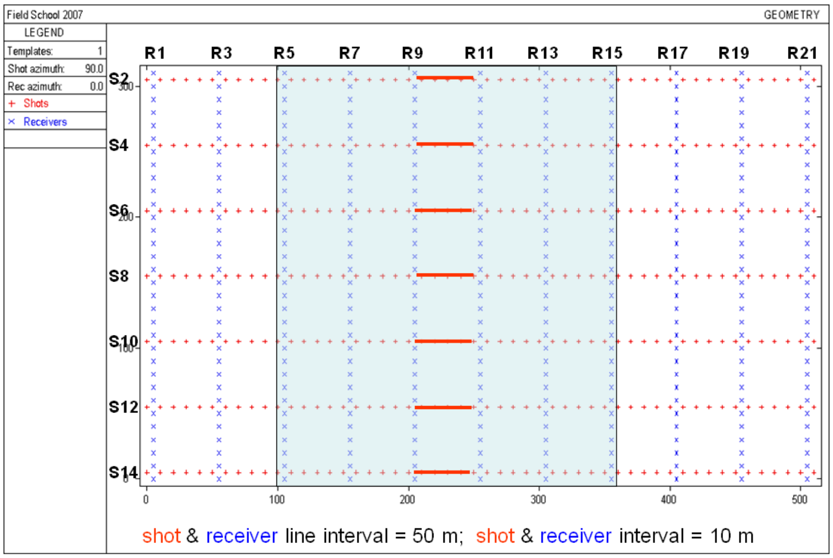



FIG. 4. Post-survey shot and receiver locations, and CMP bins.




(5a)

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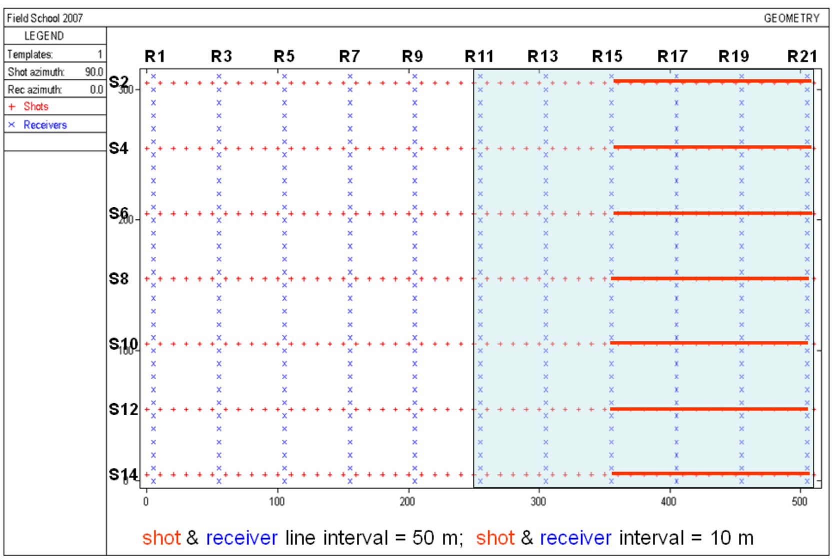


(5c)

FIG. 5. Live shots and receivers for several templates for the survey. Receiver lines were rolled during acquisition: (a) template 1 during roll-in; (b) template 3 of the survey; (c) template 6 during roll-out.

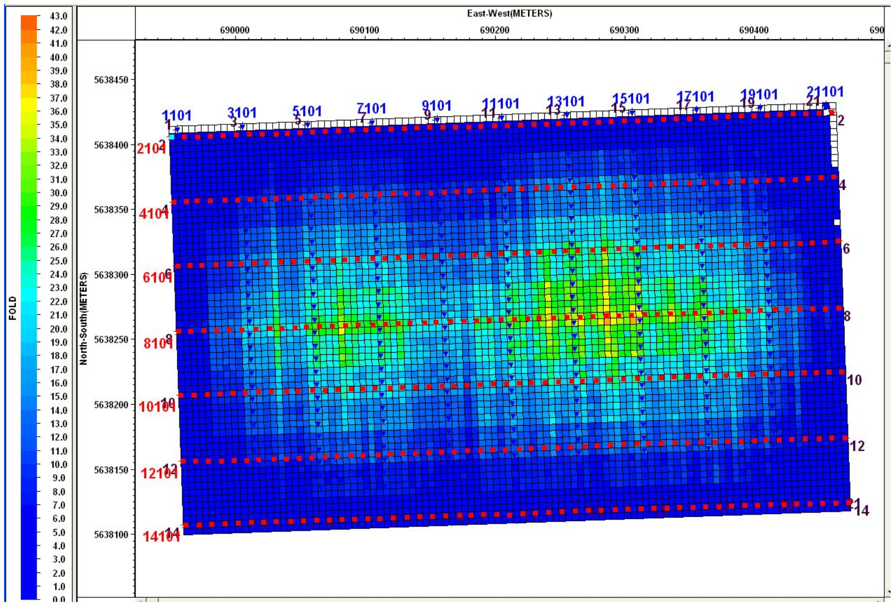


FIG. 6. CMP fold for the survey. The maximum fold is 43.

An example of a correlated shot gather (with AGC scaling) is displayed in Figure 7. Clear first arrivals are visible, but surface and airwaves dominate the record at later times. However, after application of a 40-60-140-180 Hz bandpass filter, clear reflections are observed between 250 ms and 500 ms (Figure 8).

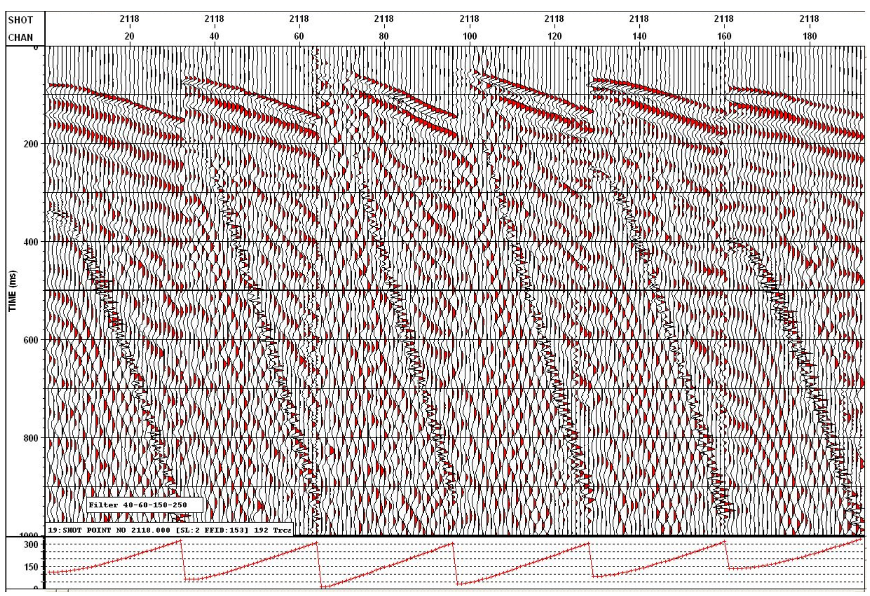


FIG. 7. Raw shot gather from the 3D survey. Note high amplitude surface and airwaves.

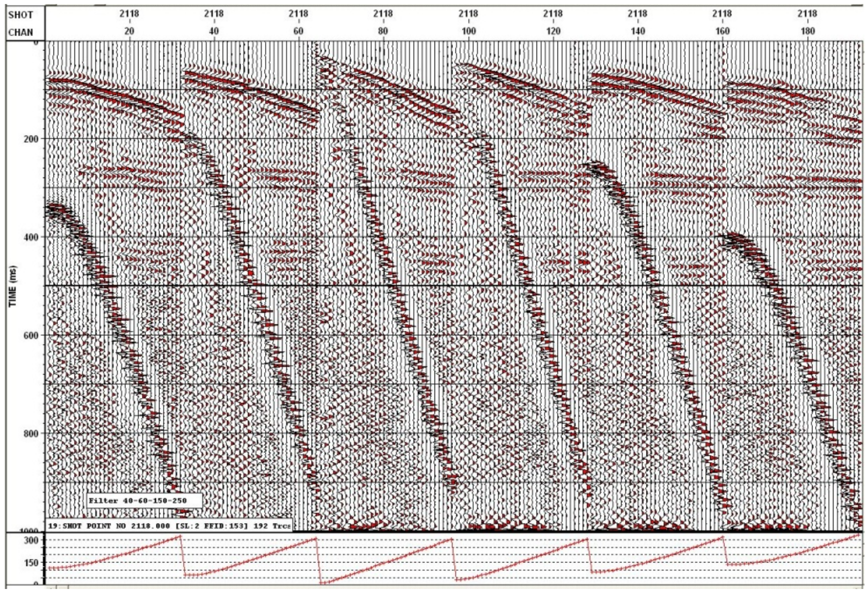

FIG. 8. Shot gather shown in Figure 7 after 40-60-140-180 Hz bandpass filter. Note reflections between 200 ms and 500 ms.

Processing of the dataset was undertaken by CREWES and followed a standard flow through to post-stack time migration. Figure 9 shows the survey elevation and near-surface velocity model obtained from analysis of first arrival data (using Hampson Russell GLI software). Positioning was undertaken using a Sokkia GSR2700 ISX RTK system.

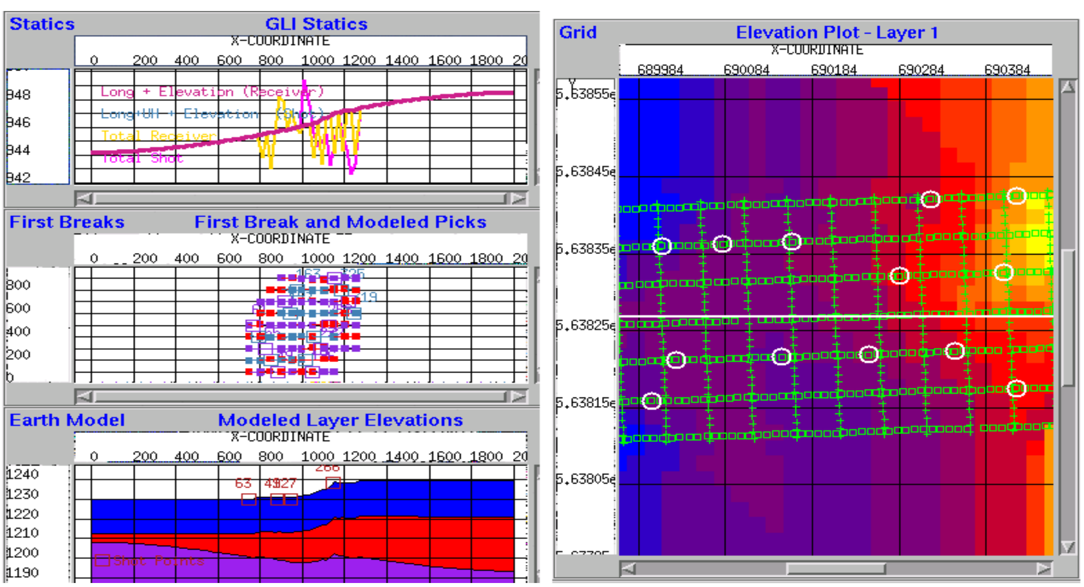


FIG. 9. Survey elevation map (right) and near-surface velocity model from the first-arrival analysis.

Examples of cross-line and in-line sections are shown in Figures 10 and 11, respectively. Most prominent in these displays is a high-amplitude east-dipping reflection between 200 ms and 300 ms, corresponding to approximate depths of 250m to 450m. This reflection event is interpreted to be from a competent sandstone that may be a regional aquifer.

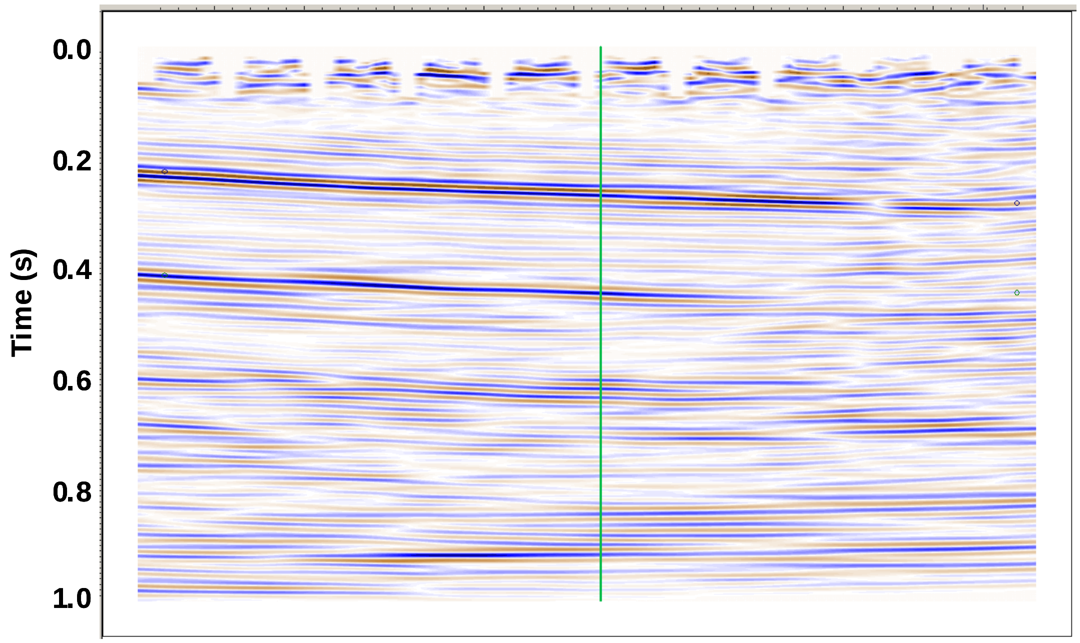


FIG. 10. Cross-line (dip) section from the processed 3D volume.

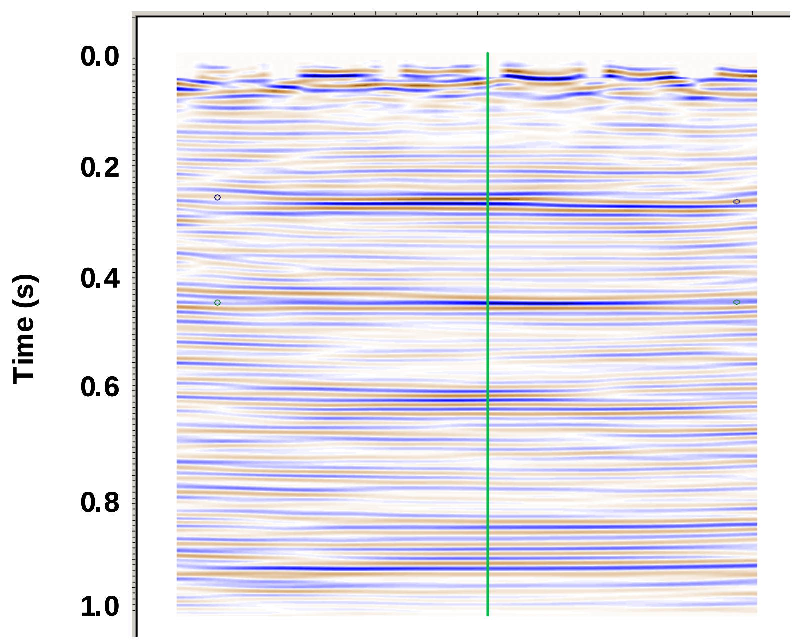


FIG. 11. In-line (strike) section from the processed 3D volume.

Figures 12 and 13 illustrate the intersections between cross-line 20 and in-lines 47 and 77 respectively, showing that the reflection character is that of an eastward dipping monocline.

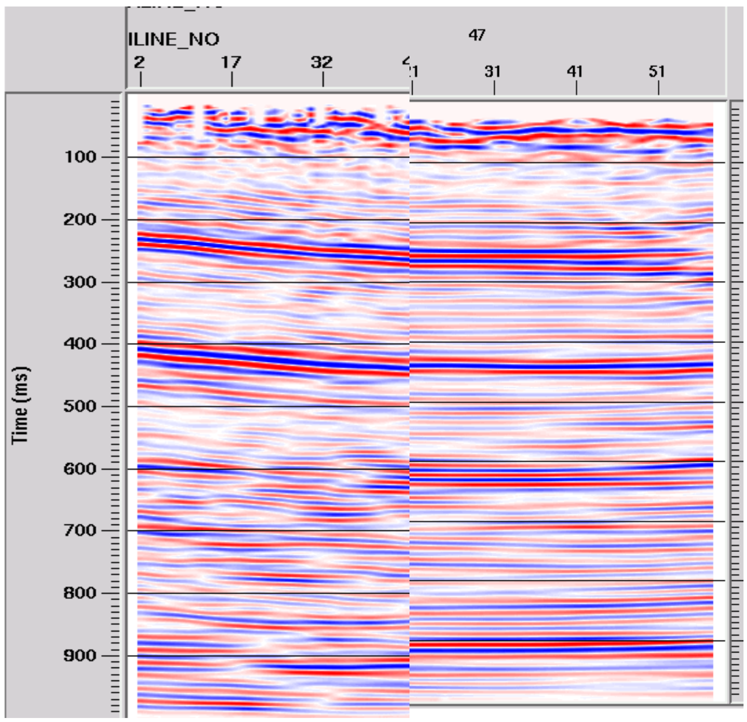


FIG. 12. Intersection between cross-line 20 and in-line 47.

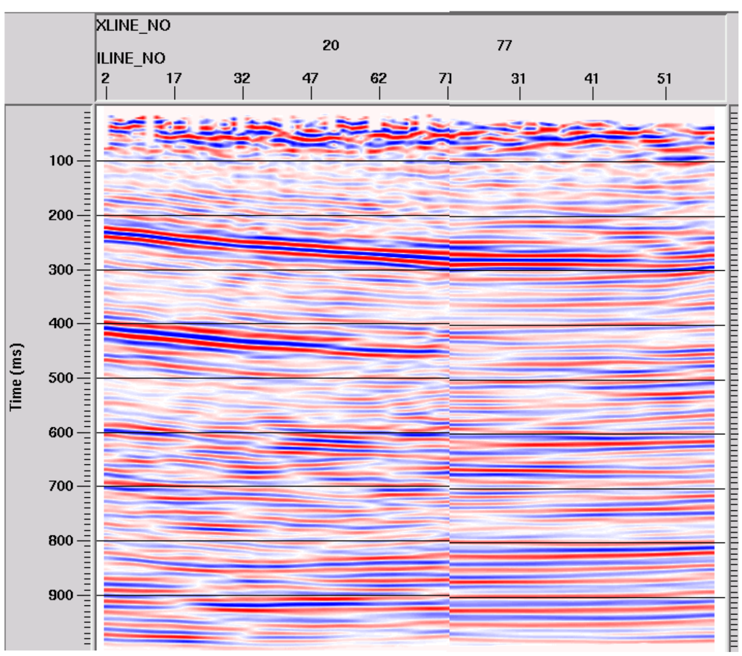


FIG. 13. Intersection between cross-line 20 and in-line 77.

## SITE DEVELOPMENT

Currently, we are proposing to further develop the site for training and research purposes, including 3D and multicomponent surface seismic programs as well as vertical seismic profiles and microseismic arrays. Shallow wells are also planned for hydrological training and research programs, as well as instruments for monitoring surface deformation. These include tiltmeters, GPS and Interferometric Satellite Radar (INSAR) systems.

## CONCLUSIONS

The results of the survey illustrate the opportunity that 3D seismic surveys provide for mapping shallow reflectors and possible aquifers. A high quality reflection seismic data volume was obtained, showing that the survey is located over the eastern flank of the triangle zone, characterised by eastward dipping reflections.

The site is currently being considered for development as a fully instrumented field training centre for seismic methods.

## ACKNOWLEDGEMENTS

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